Benthic microalgae and bacteria facilitate carbon and nitrogen retention in shallow photic sediments

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Sediments in shallow coastal bays are sites of intense biogeochemical cycling facilitated by a complex microbial consortium. Unlike deeper coastal environments, much of the benthos in shallow coastal bays is illuminated, and consequently, benthic autotrophs such as benthic micro- and macroalgae play an integral role in nutrient cycling. The objective of this study was to track carbon (C) and nitrogen (N) uptake into the sediments in the presence and absence of macroalgae, often a symptom of eutrophication in coastal bays. We used a dual stable isotope tracer approach in combination with compound-specific isotope analyses of hydrolzable amino acids (HAA) and phospholipid-linked fatty acids (PLFA) to quantify the uptake and retention of C and N within the bulk sediment, macroalgal, benthic microalgal, and bacterial pools. Stable isotope tracers ($^{15}NH_4^+$ and $H^{13}CO_3^-$) were added to the mesocosms for the first 14 days of the 42-day experiment.

Sediments exposed to ambient light/dark cycles rapidly took up label and retained the label for 4 weeks after isotope additions ended. Benthic microalgae dominated sediment uptake of ^{13}C and ^{15}N, initially accounting for 100% of total uptake. Over time, heterotrophic bacterial uptake became relatively more important, increasing from 0% on Day 1 to 30-40% on Day 42, indicating a close coupling between benthic microalgal and bacterial production. In macroalgae treatments, macroalgae sequestred ^{13}C and ^{15}N while growing, but sediment ^{13}C and ^{15}N uptake decreased by 40% compared to treatments without macroalgae. This was likely due to shading of the sediment surface by macroalgae, thereby decreasing benthic microalgal production, which in turn decreased bacterial production. Overall, the sediments serve as a sink for C and N through uptake and retention by the microbial community. This may play an important role in buffering the effects of increased nutrient loading; however, macroalgae reduce the retention of C and N within surface sediments, diminishing the role of the microbial community in nutrient cycling processes.

Th and U incorporation into xenotime during partial alteration by alkali-bearing fluids

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Xenotime [(Y+HREE)PO_4], has been partially altered with respect to its Th and U content in sealed Au capsules utilizing the piston-cylinder apparatus (CaF_2 assembly, cylindrical graphite oven; 1000 MPa, 900 °C; 8 days) and cold seal autoclaves on a hydrothermal line (500 MPa, 600 °C; 16 – 24 days) and a series of alkali-bearing fluids (20 – 25 mg) including 2N NaOH, 2N KOH, and $Na_2Si_2O_5$ + H_2O. The xenotime used (20 mg; Th and U below EMP detection limit) is a near gem quality crystal from a pegmatite, Northwest Frontier Province, Pakistan. Thorium and U were added to the solution as 5 mg $ThSiO_4$ + ThO_2 + SiO_2 or UO_2 + SiO_2, respectively. The fluid composition chosen was based on speculations made by Hetherington and Harlov [1] regarding partial metasomatic alteration of xenotime megacrysts from a fluid-rich granitic pegmatite, Hidra, S Norway. Utilizing BSE imaging, EMP analysis, and TEM, evidence for Th and U mobility and subsequent partial alteration of the xenotime grain via coupled dissolution-reprecipitation [2] is seen in each experiment. This takes the form of remobilised $ThSiO_4$ or $USiO_4$ enriching a portion of the xenotime via the coupled substitution reactions $Th^{4+} + Si^{4+} = REE^{3+} + P^{5+}$ or $U^{4+} + Si^{4+} = REE^{3+} + P^{5+}$, respectively. Alteration takes the form of patches with sharp compositional boundaries, which extend from the rim of the xenotime grain into the interior. They are not overgrowths. The results from these experiments support the hypothesis that similar Th- or U-enriched or depleted patches with sharp compositional boundaries observed in natural xenotime could be the result of alteration from alkali-rich fluids via dissolution-reprecipitation. This could yield information concerning the nature of the fluid responsible for the formation of the patches as well as allow for the possible dating of single or multiple metasomatic events assuming that all pre-existing radiogenic Pb has been removed during alteration. The existence of altered xenotime in nature suggests the presence of alkali-rich fluids, probably in the form of hydroxides, during fluid-aided mid- to high-grade metamorphism or igneous processes, in alkali-feldspar bearing rocks due to the infiltration of H_2O-bearing fluids.

[1] Hetherington and Harlov (2008), *Am Mineral*, **86**, 806. [2] Putnis, (2009), *Rev Mineral Geochem*, **70**, 87.